DISEASES OF METABOLISM AND NUTRITION

VON NOORDEN

No. VI.
DRINK RESTRICTION


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DRINK RESTRICTION.

DISEASES OF
METABOLISM AND NUTRITION.

A SERIES OF MONOGRAPHS

By Prof. Dr CARL von NOORDEN,
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Authorized American Edition.
Edited by Boardman Reed, M.D., Philadelphia.

I.—Obesity: the Indications for Reduction Cures
II.—Nephritis
III.—Colitis: or Membranous Catarrh of the Intestines (*Colica Mucosa*)
IV.—The Acid Autointoxications
V.—Saline Therapy
VI.—Drink Restriction (*Thirst Cures*)

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DRINK RESTRICTION

(Thirst Cures)

PARTICULARLY IN OBESITY:

BEING PART VI OF SEVERAL

CLINICAL TREATISES

ON THE PATHOLOGY AND THERAPY OF

DISORDERS OF METABOLISM AND NUTRITION.

BY

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NOTE BY THE AMERICAN EDITOR

Professor von Noorden's monograph on Drink Restriction is a most instructive deliverance upon a subject of the highest practical importance—one which should appeal strongly to both the medical profession and the laity. Especially in this country, where hot-water drinking and colon douching have been carried to an irrational, ridiculous, and often very harmful excess by the advice of certain irregular practitioners and cranks, will his warnings be timely. Unfortunately, not all physicians realize that not only does every mouthful of surplus food add to the burdens of all the digestive and excretory organs, instead of strengthening the body, but that every superfluous ounce of liquid ingested adds to the labor of the heart and kidneys, besides having to be for the most part forcibly extruded by the stomach into the small intestine before it can be absorbed. It is sad to think how many victims of dilated heart, dilated stomach, and of Bright's disease have been encouraged to drink themselves to death, and how many patients afflicted with obesity have shortened their lives by continuing excessively fat, with all its discomforts and dangers, to the end of the chapter, waterlogged because of unrestricted drinking.

Many persons unquestionably drink too little, of water particularly, but Professor von Noorden has clearly proved that a great many others drink too much.

B. R.

1831 Chestnut Street,
Philadelphia, *April 25, 1905.*

I. HISTORICAL AND CLINICAL REVIEW

(a). *The Restriction of Liquids in Diseases of the Blood Vessels, the Stomach, the Heart, the Kidneys, and in Diabetes Insipidus*

THE attempt has been made to utilize in manifold diseased conditions the powerful influence which may be exerted upon the body by a restriction of liquid ingesta.

It was in the treatment of certain affections of the vascular apparatus that the advantages of under-nutrition and of thirst-cures first came to be appreciated.

Hippocrates (1) was the first to advise rendering a patient with heart disease "siccum et siccissimum" by limiting the amount of solid and liquid ingesta. Several clinicians of the Middle Ages, among them Valsalva, Albertini (2), and Montagni (3), advised a similar procedure, and in addition recommended repeated blood-letting as a valuable step towards reducing the quantity of the blood, when combined with a gradual reduction of solid and liquid food. Later reports by Bellingham (4), Tufnell (5), and Vanizetti (6), in cases of aneurism treated in this way, bring us down to the modern literature on the subject.

The marked and significant symptoms of aortic aneurism explain why, particularly in this disease, physicians returned again and again to restriction cures.

S. Laache (7), Moritz Schmidt (8), when they saw the surging blood current finally burst the vessel walls, what was more rational than striving to lessen the amount of the blood?

But restriction of food was then considered equally or even more important than restriction of liquids, and the cures reported by the above-named authors cannot, therefore, be designated as pure thirst-cures. As to these deprivation cures, the credit for having placed in the foreground the restriction of liquids especially, and for having recognized correctly its effect in thickening the blood, belongs to Schroth (1800-1856). He instituted what was called a "roll cure" (Semmelcur), and allowed his patients to eat as many dry, thoroughly baked rolls as they cared to, and, in addition, mushes made from rice, barley, etc. The only liquids that the patients were allowed to take during the first week of the cure were a little oatmeal gruel mixed with sugar and lemon-juice; the quantity of this liquid pabulum was gradually reduced to a wineglassful daily, until finally the patients were allowed this amount only every other day. The patients were forced to subsist on this minimum of liquids for weeks; if the thirst became insufferable they were allowed a piece of roll dipped in wine or half a glass of wine. Cold packs given every evening were made a part of this treatment.

Carried out in this rigid manner, Schroth's cure was naturally a very severe procedure. Some of the cases developed signs of scurvy, and a few of them died.

A rise of temperature above 40° C. was reported in a considerable number of instances.

Jürgensen (9), who tested the value of this method, added half a bottle of wine to the dietary. He also showed conclusively that no vicarious absorption of liquids through the intact skin occurred, as Schroth had postulated. He obtained definite therapeutic results in cases of old syphilis, in gastrectasis, and in chronic peritoneal exudates.

Schroth's cure in the form proposed by its originator naturally did not maintain its popularity for a long time. The method was far too trying and inconvenient to the patients; and, in addition, its inventor seemed incapable of fairly judging of its limitations, so that he proclaimed it a universal panacea for all ills. However, the good results indisputably obtained by Schroth in many disorders attracted the attention of the profession to his method. Thus Jürgensen relates as follows:

"Professor Bartels found several years ago that a case of gastrectasis that he had treated without success for a long period of time was cured in a so-called 'Schroth Institute.' This induced him thenceforth to try a similar method in suitable cases that came to his clinic."

Since that time the use of a dry diet has occupied a prominent place in the treatment of gastric dilatation, notwithstanding some of the objections that have recently been formulated against it by Albu (10), for instance. In this disorder the advantages of the dry

diet are quite clear. Whenever the evacuation of the gastric contents becomes difficult the greater curvature of the stomach is stretched and dilated and occupies a position considerably lower than the pylorus. It is clear that solid ingesta can more readily be raised to the level of the pylorus than fluids, for the latter are mechanically more difficult to propel upward than solids. Fluids, moreover, are more voluminous in proportion to their nutritive value than solid articles of food. When we consider, furthermore, that practically no water is absorbed by the walls of the stomach and that it consequently acts as a dead weight in the stomach whenever it cannot readily pass through the pylorus, we can easily understand why a dry diet spares the organ when it is dilated and the tone of its musculature is weak. As a matter of fact fairly good results are obtained from a restriction of liquids in such cases. I need hardly emphasize that the good effects derived from this practice are more striking and more rapid in cases of simple atony of the stomach than in pyloric stenosis.

[On the other hand there are conditions in which the moderate drinking of water or other non-irritating liquid during, or shortly after, meals may lessen the danger of overdistention and dilatation of the stomach. This is especially true of spasmodic contraction of the pylorus (pyloro-spasm), from either hydrochloric or organic acid excess—hyperchlorhydria or any form of marked hyperacidity. The non-

effervescent alkaline waters are, of course, particularly effective in overcoming such contractions, since they facilitate the onward propulsion of the gastric contents by diluting them as well as by directly neutralizing their excessive acidity. In organic acidity, however, from fermentation, associated with a diminished secretion of hydrochloric acid, prolonged alkaline treatment would be injurious by still further depressing such secretion. In cases of this kind, therefore, plain water, neither ice-cold nor very hot, is preferable and will often, by merely diluting the over-acid contents, relieve the spasm and thus help to unload the viscus. Manifestly the acid wines and malt beverages would aggravate, instead of remedying, the conditions just described.—Ed.]

It is a peculiar fact that the thirst cure that was so commonly employed in the Middle Ages in the treatment of cardio-vascular disorders was not rescued from oblivion even by Schroth's cure. For otherwise the book that Oertel (11) published in 1884, entitled "Therapy of Cardio-Vascular Disorders," could not have surprised the profession as it did, nor could it have become so epoch-making. The work that Körner (12) published some time before Oertel must, it is true, be considered a precursor of the latter's ideas, and some credit, therefore, is due this author, too, for having revived the idea of restricting the fluid intake as a therapeutic measure. Oertel proposed, in cases of serious failure of compensation, to dehydrate the

organism by reducing the amount of liquids ingested and by stimulating the elimination of water through the skin and the lungs. The means that Oertel employed to this end were muscular exercise, diaphoretic baths and injections of pilocarpin. After a sufficient quantity of water had in this way been withdrawn from the body, this improved condition was to be permanently maintained by the ingestion of a diet that contained little fluid.

Some of the postulates upon which Oertel based his conclusions were, it is true, open to criticism. Thus he presupposed the existence of an hydræmic plethora in his cases of failing cardiac compensation, *i. e.*, a condition of the blood in which the plasma was abnormally diluted and the total quantity of the blood increased; he claimed that it was due to these two factors that the weakened heart muscle was overtaxed. In order to determine whether or not the organism was in a condition of hydrostatic equilibrium, he proposed the so-called "determination of the difference" (Differenzbestimmung) between the intake of water per os and the output of water in the urine. These determinations, as was later shown, did not grant a true insight into the water equilibrium of the organism, for they did not take into consideration the amount of insensible perspiration, a factor that to this day has never been accurately determined in cases of heart disease. Notwithstanding this defect, Oertel's "determination of the difference," combined with daily weighing of the patient, offers a convenient and

practical means for studying the water economy of the body.

It is much more difficult to determine how much importance should be attached to the theoretically interesting postulate advanced by Oertel, that there is in these cases a condition of "hydræmic plethora." A large number of investigations have been published on this subject, the results of which are altogether contradictory. Without entering into the details of all these investigations,[1] a resumé of all the results obtained may be given in this place:

We know nothing definite so far in regard to the volume of blood in the different vascular areas in cardiac disease, and, in particular, in cases of failing compensation, and we do not know positively whether genuine "plethora" occurs or not. All that we do know is that in compensatory derangement—and possibly without it in heart disease—the normal distribution of the blood in the arteries and the veins is changed, the arteries on an average containing less, the veins more, than normal. It is unnecessary to discuss the important question how this factor determines, on the one hand, a more forcible impulse of the diseased heart, on the other hand, progressive dilatation of the right side of the heart.

For well-compensated cardiac lesions the concen-

[1] For the literature see Gumprecht, "Diseases of the Circulation," in Eulenburg-Samuel's "Lehrbuch d. Allg. Therapie"; also Jürgensen, in Nothnagel's "Handbuch der Speciellen Pathologie und Therapie."

tration of the blood (removed in the ordinary way by a small cutaneous puncture or puncture of a vein) is normal. Occasionally hyperglobulia and increased concentration are formed, particularly in lesions of the right side of the heart, and in congenital heart-diseases. In all of the cases in which the blood was found abnormally dilute (anæmia or hydræmia), complicating diseases, insufficient nutrition, etc., could be incriminated.

In cases of disturbed compensation, the percentage of water in the blood was sometimes found somewhat low, but much more frequently it was found normal or a little increased (in part as a result of the decrease of erythrocytes and hæmoglobin, in part as a result of genuine hydræmia, *i. e.*, hypalbuminosis of the plasma). In the cases in which considerable degrees of hydræmia were found, the patients were, as a rule, very much reduced, or they were suffering from complicating diseases. One is not, therefore, justified in speaking of typical *hydræmia,* that is, the result of pure compensatory disturbances, the existence of which Oertel has postulated.

It will be seen that the results of objective blood examinations are not favorable to Oertel's theory. The fundamental question is not, however, touched by this result, for it is immaterial what becomes of the water, *i. e.,* whether it remain in the blood vessels, causing plethora and hydræmia, or whether it diffuses into the tissues or is excreted through the lungs, the skin or the kidneys; the fact remains that the daily

task imposed upon the heart is greater if much water is ingested than if small quantities only are taken. All the water that enters the stomach must pass through the heart and arteries before it reaches the emunctories of the body. Even if the quantity of water that enters the blood at any one time is too small to be estimated by our means of measurement, we know nevertheless that the surplus water must circulate several times through the heart and the arterial tree before it can be eliminated from the blood. No one will, therefore, seriously argue that the total labor performed by the heart is not greater if large quantities of water are ingested than if the amount of water drinking is restricted to a minimum—this even when hydrostatic equilibrium is fully maintained and the average concentration of the blood remains normal.

Moreover, all objections (based on blood examinations) to the contrary nothwithstanding, the validity of Oertel's claims has been fully borne out by practical experience: restriction of fluids signifies sparing the heart. We consider Oertel's procedure to be a therapeutic achievement of the first rank. If, recently, several writers have again formulated objections against the method that are based upon blood examinations alone, and if these authors declare the restriction of liquids to be useless, then this merely shows how dangerous and how short-sighted it is to base therapeutic suggestions upon a single clinical method of examination.

In our opinion restricted water drinking in heart

diseases is of inestimable value as a prophylactic measure. As soon as disturbances of compensation supervene this measure is to be considered merely as an adjuvant to treatment, and other means, digitalis, etc., become more important. We know of cases, however, from our personal experience in which a variety of heart-regulating and diuretic medicaments failed, and in which improvement did not set in until the liquids were restricted; often even after an energetic thirst-cure the heart and kidneys would begin to react to drugs. If one decides to institute an energetic thirst-cure—and this procedure is always somewhat heroic—it is best, according to our experience, to restrict or stop all solid food as well as liquids, *i. e.,* to induce the patients to *fast* completely for a few days and to take no liquids whatever during this period.

It is an old and well-known fact (and one that has been demonstrated repeatedly in animals that were submitted to starvation as well as in human subjects who voluntarily underwent a prolonged period of fasting) that a fasting organism requires an extraordinarily small amount of water. Even if a fasting subject is allowed water *ad libitum,* it will be found that he rarely takes more than one liter a day, and frequently less. All observers, moreover, agree that hunger, with or without restriction of liquids, is borne far better than the restriction or the complete withdrawal of liquids alone. We have had the same experience in patients suffering from cardiac œdemas,

and find our observations in a measure corroborated by the statements made by Karell, F. Hirschfeld, S. Laache (13) in regard to the therapeutic value of under-feeding in cardiac disorders.

Inasmuch as the older methods of blood examination (specific gravity, percentage of water, corpuscle count, hæmoglobin determinations) had failed to offer a satisfactory interpretation for these good therapeutic results, newer methods of blood examination have recently been adopted in an attempt to solve the problem, chief among them the cryoscopy (freezing-point determination) of the blood and the determination of its electric conductivity. These methods have broadened the field of investigation, but have so far thrown no new light on the subject. Fr. Kraus (14), basing on these newer methods and their results, has recently submitted the theoretical justification of Oertel's cure to a searching criticism, and has at the same time pointed out many promising paths for future investigations to follow. He claims, in particular, to have already found a chemico-physical index for the beginning of failing compensation; this moment, and with it the indication to restrict the ingestion of liquids, is said to have arrived when the quotient $\frac{Cc}{C}$ (Cc=concentration of electrolytes, *i. e.*, acids, bases, salts; Cc=total concentration) begins to be lowered in the urine.

Fr. Kraus, however, also agrees that for the present, practical experience is a much better criterion of the

value of Oertel's method than theoretical considerations of any kind.

We agree fully with this view and at the same time declare it very improbable that our understanding of this question will ever be considerably advanced by studies concerned, as heretofore, with determinations of the chemical and physical concentration of the blood. The disadvantages of abundant water drinking in patients with a weak heart must not be sought in an accumulation of the water in the cardio-vascular apparatus, but

(1) In the forced transputation of large quantities of liquid through the blood stream.

(2) In the diffusion of water into the tissues, thus causing swelling, compression of capillaries and an increased resistance of the blood stream.

The first case demands regulation of the ingestion of liquids whenever the heart is to be spared, that is, prophylactically before the onset of any compensatory disturbances.

The second case presupposes that the disturbance in the water equilibrium has already begun. The onset of this condition, in our opinion, can much more readily be estimated from fluctuations in the diuresis and of the weight of the patient than from examinations of the blood. Weighing the patient is even more important than searching for œdema. The patient may gain 5 or 6 kg. from an accumulation of water, before any œdemas become apparent, even in most careful search. During this prehydropic period, that

is so important in the prognosis of the case and the treatment of the patient, the blood often does not show the slightest percentage change of concentration.

We habitually advise sufferers from heart disease to drink sparingly, even when compensation is in no way disturbed, and we recommend that they ingest no more than from 1250 to 1500 c. c. of liquid—including everything fluid in the diet. Precisely as a preventative of further trouble in cases showing incipient cardiac disturbances, *e. g.*, arhythmia, contractions in arterio-sclerotic subjects, etc., does this means appeal to us. In fully developed hydrops we proceed more energetically, as a rule, but do not decrease the amount of fluid ingesta below 1000 to 800 c. c.

Von Noorden (15) some years ago applied Oertel's doctrine to renal diseases, and showed that in many cases of nephritis the restriction of liquids is an important postulate of rational treatment, particularly in contracted kidney.

In the latter disease the heart, above all, is affected, and there is always danger of early cardiac incompetency. Here the restriction of liquids is an excellent prophylactic, and even at a stage of the disease when cardiac dilatation and weakness are fully developed do we see good results from this method. The objections that H. Strauss (16) has formulated against this procedure, and that are largely based on blood examinations (increase in the molecular concentration of the blood in cases of contracted kidney), can hardly be considered valid in view of the positive therapeutic

results that have repeatedly been obtained; they only show again how dangerous it is to attach dogmatic importance to one single method of examination. One is never justified in ignoring any fact for the sake of maintaining a theory, and it certainly is a fact that many cases of contracted kidney, although restricted in their water drinking, enjoy the best of health for many years, notwithstanding the fact that the molecular concentration of the blood is increased. We must conclude from all this that studies of the molecular concentration of the blood are no practical or reliable index of the subjective well-being or the progress of these cases; and one is certainly not justified in reversing the proposition and utilizing fluctuations in the molecular concentration of the blood to invalidate the usefulness of certain definite and well-established therapeutic rules. We call particular attention to the fact, moreover, that von Noorden expressly advocated the restriction of liquids for none other than cases of contracted kidney and for certain stages of acute nephritis.

Von Noorden in his first publication ("Congr. f. innere Medicin," Carlsbad, 1899) mentioned the fact that in renal disorders great care must be exercised lest the restriction of fluids lead to a decreased elimination of the urinary end-products of metabolism (urea, uric acid, organic bases, salts, etc.). Preliminary investigations, however, that were presented in Carlsbad and at the Manchester meeting of the British Medical Association, 1902, showed that in most cases of chronic contracted kidney the elimination of urinary

solids was not reduced when the fluid intake was restricted to $1\frac{1}{2}$ or even $1\frac{1}{4}$ liters. Since then L. Mohr and C. Dapper (17) have reported exhaustive clinical and experimental studies on this subject from von Noorden's clinic that fully corroborate these preliminary findings.

Other clinicians have reported corresponding results —Pel, Roth and Kövoesi, Hale White (18); and in the discussion on Bright's Disease at the Oxford meeting of the British Medical Association all the speakers agreed with von Noorden's views.

As soon as the patients enter the proper uræmic stage of the disease, no further advantage can be expected from the restriction of liquids. The method has also proven futile in chronic parenchymatous forms of nephritis with œdemas, although—theoretically—we should expect good results *a priori* from dehydration of the organism.

We can add to this cursory review of the application of thirst-cures in various diseases the use of water-restriction for therapeutic purposes in *Diabetes insipidus*. The reports on the results obtained in this disorder are contradictory. According to our own experience the gradual reduction of the fluid intake gives excellent and permanent results in isolated cases, in other cases again absolutely no effect is seen. The factors that determine the result in this disease are still so obscure that it is hardly worth while to enter into a detailed discussion of the subject in this place.

(*b.*) *The Restriction of Liquids in Obesity*

In all the diseases enumerated the regulation of the fluid intake remains in the hands of the physician, and many a fight must be waged with the always thirsty patient. In *one* disorder only, namely, in *obesity,* does the popular mind recognize the therapeutic value of restricting liquids, and to-day it is one of the unassailable doctrines of lay-medicine that abundant water drinking makes fat and that the restriction of liquids favors a loss of flesh.

Even among physicians the idea that the restriction of liquids, particularly the avoidance of soups and the reduction of water drinking during meals, favors a loss of flesh enjoys widespread popularity.

The recommendation to restrict the liquid intake in order to reduce obesity goes far back, to the days of Plinius Secundus. A detailed account of these ancient regulations, as well as of similar doctrines enunciated by Panaroli, Ettmüller, and in recent years Dancel and Steinbecher, can be found in the excellent historical review compiled by Ebstein (19).

But the chief apostle of this dogma in our own day was Oertel.

Oertel primarily recommended the restriction of liquids from the standpoint of hydrodynamics. The beautiful results obtained from this practice in cardiac disorders encouraged this view, for the restriction of liquids contributes towards sparing the heart, an

organ whose strength and resisting powers are always endangered in obesity.

In the course of his therapeutic studies with this method in sufferers with heart disease, Oertel frequently noted a loss of weight, and a reduction in the volume of the body that he did not feel justified in attributing exclusively to the loss of water. As these patients claimed that there was no difference in their appetite nor any decrease in the ingestion of solid food, and as Lorenzen (20) in a report published from Strümpel's clinic chronicled similar observations, Oertel assumed that the reduction of liquids did not merely produce a dehydration of the tissues and greater concentration of the blood, but actually an oxydation of the fatty tissues.

The explanation that Oertel advanced for this process seems rather forced to us to-day, in the light of our present knowledge; he claimed that an intimate relationship existed between the blood vessels and the adipose tissue; the formation of this tissue, according to Oertel, occurring always in or around the adventitia of small blood vessels, arteries, veins and the capillaries issuing from them. As soon as the blood vessels became less filled, as a result of the restriction of liquids and the resulting concentration of the blood, "obliteration of blood vessels and anæmia involving large or small areas" supervened; associated with this, he postulated, "complete arrest of the nutrition of adjacent tissues, dissolution and absorption of their elements" occurred. The fat that was absorbed in

this way was destroyed by oxydation as soon as a larger quantity of arterial blood was again carried to the tissues, as a result of the relief of stasis, and in this way the energy of the individual cells was restored. So much for the complicated explanation offered by Oertel, an explanation that satisfied no one—neither the physiologist, the anatomist, nor the clinician.

In addition to restricting the total amount of liquids (including the water contained in the different articles of diet), Oertel also recommended separating food and drink; for, he argued, where solid food is taken abundant gastric juice is secreted and in this way the concentration of the blood favored, whereas, on the other hand, the drinking of liquids with meals causes great dilution of the gastric juice, retards gastric digestion and favors the development of dyspepsia.

The so-called Schweninger Reduction Cure that is much spoken of in Germany has adopted particularly this latter prescription of the Oertel method, *i. e.*, the separation of fluid and solid food.

Schweninger (21) says: "Comparative investigations show that dry, small meals produce a reduction of obesity much more rapidly than meals of the same size that consist in part of liquids. This is not easy to explain. I maintain that the fluid necessary to form the digestive secretions is delivered from the circulating tissue-juices with much greater facility when water is taken with meals than without; for this reason we find that a subject living on a dry diet suffers more or less intensely from thirst while eating the solid

meal. As soon as the organism is deprived of water in this way and the latter is not replaced at once by drinking, the body must manufacture water from its own fatty tissue; this it does by splitting the fat into simpler molecules, *i. e.*, by self-combustion. As soon as this act of fat-cleavage is finished, *i. e.*, about one hour after eating, small quantities of liquids may gradually be taken." So much for Schweninger. This hypothesis, still more than the ideas advanced by Oertel, contradicts all the facts of physiology that we know to be true to-day.

It is well known that the doctrines of Oertel and of Schweninger enjoy a wide popularity among physicians, and are accepted as true by many members of the medical profession and of the laity. How often do we hear a patient who is undergoing a reduction cure for obesity say, "I am Schweningering." Many factors have contributed to the popularity of Schweninger's method: In the first place, the association of ideas that connected this method with the world-renowned figure of Prince Bismarck, for it is true beyond doubt that Schweninger exercised an influence over the latter greater than any other physician; in the second place, the great facility with which the Schweninger cure could be undertaken, as compared to the great inconveniences and discomforts that had to be undergone when carrying out any of the other so-called "reduction cures." In addition, the various dietetic prescriptions that were formulated by such men as Harvey, Banting, Oertel, Ebstein, Hirschfeld,

and Kisch were so complicated, the essentials were so obscured by a mass of detail, that the practicing physician, who prescribed his reduction cures from a book, and the patient, too, who often gleaned his information from the same source, were unable to understand all that was expected of them, and, consequently, found it impossible to carry out the reduction cure according to the rules of whatever system they had decided to follow.

How simple, by contrast to these complicated regulations—that have only within recent years been reduced to a concise and clear, common formula (chiefly by von Noorden[2])—the prescriptions of Oertel, or still more, of Schweninger!

All that was asked of the patients was to omit liquids, in particular soup and water, from the diet (Oertel), and this restriction, moreover, was to be imposed only at certain times (Schweninger); otherwise one could eat and gormandize to one's heart's content. This method was far too tempting not to be tried at once by hundreds and thousands of men and women. Now it happens to be an established fact that occasionally the restriction of liquids (in the sense of Oertel or Schweninger) causes considerable loss of weight and fat without the operation of any other *apparent* factor. But according to our experience and the experience of most physicians in the course of the last two decades, these cases are great exceptions, that,

[2] Von Noorden, "Obesity," in Nothnagel's "Handbook of Special Pathology," vol. vii, 1900.

as we will show below, can be explained in a very simple manner. As a matter of fact the restriction of liquids—notwithstanding the fact that the laity and superficial physicians attribute commanding importance to this measure—constitutes only a very insignificant and unessential part of the Oertel-Schwenninger method for reducing obesity. Oertel, in addition to restricting liquids, orders a pretty strict dietetic reduction cure—not differing materially from the old Banting cure; Schweninger in his sanatoria submits his patients, in a routine manner, to a very vigorous course of treatment (a scanty and lean diet, massage, gymnastics, etc.), and incidentally also restricts the liquids; the Schweninger course is probably the most rigorous and severe treatment that is administered anywhere, so that one need not be astonished to find that many who undergo this cure emerge from the sanatorium broken in strength and health.

The great popularity that Oertel's and Schweninger's ideas enjoyed among practicians in general, and among the sick, did not by any means extend to scientific circles.

Hirschfeld (23), in his monograph, was one of the first to demonstrate that the influence of water restriction upon the disassimilation of adipose tissue was neither theoretically nor practically proven. Von Noorden (23) arrived at similar conclusions, and in his book "Obesity" clearly outlined the significance of thirsting and the indications for the restriction of liquids in the treatment of obesity. Stadelmann (24)

and Rosenfeld (25) more recently also occupied an attitude towards this question that is altogether antagonistic to the doctrines and the methods of Schweninger.

The important objections that have been formulated against Oertel and Schweninger are based in part on theoretical considerations, in part on practical experience. If the criticism of their views has been severe—almost too severe in some instances—one must never forget that the apodictic manner in which Oertel and Schweninger advanced their ideas on the disassimilation of fat in the organism, without advancing any definite proof for the validity of their arguments, was enough to discredit them in the eyes of scientifically thinking critics. If we carefully review, however, the small number of investigations that we possess in regard to metabolic processes in thirsting animals and human subjects, we will find that the claims of the followers of Oertel and Schweninger are by no means altogether absurd. A review of the literature on this subject may be given in the following paragraphs.

II. REVIEW OF PHYSIOLOGICAL INVESTIGATIONS CONCERNING THE EFFECT OF THIRSTING ON THE ORGANISM.

THE purely experimental studies that have been made on the effect of thirsting upon the organism need merely be mentioned in a cursory manner. Longet, Birsch-Hirschfeld, Chossat, Luciani, Bufalini, Scheffer, Schuchardt and Falck (26) have published such investigations; their chief task was to determine how long thirsting animals could survive. It was shown that the effect of thirsting was much more intense than the effect of fasting. The subjective tortures of thirst have been vividly described in the works of African explorers, *e. g.*, v. Rohlf, Nachtigal and others, also in the work of Strübell (27). Pernice and Scagliosi (28) have performed pathologico-anatomic studies on animals dead from thirst; they found tissue atrophy and inflammatory changes in various organs and, in particular, a hemorrhagic form of glomerulo-nephritis.

Other investigations are concerned with the effect of thirsting upon the blood. A large number of the data submitted do not refer exclusively to changes in the blood in thirsting animals, but also in animals that were submitted to diaphoretic measures, that were artificially heated, etc.—all procedures that were intended to produce greater blood concentration, but that need

not be discussed in detail in this place. To this category belong, *e.g.*, the investigations of Löwy, Friedländer, Hammerschlag (29) and others. A study of Gürber (30), who found that in a thirsting frog *the number of erythrocytes* was increased, is concerned exclusively with the withdrawal of water, and so, also is that of Von Westendorf (31), who showed that in a thirsting dog the osmotic pressure and the specific gravity of the blood were increased; he also called attention to another interesting fact, viz., that the lowering of the specific gravity of the blood, which normally occurs after venesection, does not occur in a thirsting dog, because no water can be yielded to the blood from the dehydrated tissues of such an animal.

The investigations of Nothwang (32) lead to the studies on the effect of thirsting on metabolism; in his paper a summary of the older literature on the subject may also be found.

Nothwang made his studies on pigeons that were fed on air-dried peas. He calls attention to the experimental difficulties of studying the effect of thirsting on animals; for, as thirsting animals soon refuse to eat, the effects of fasting are soon added to those of thirsting. In inanition from lack of food the tissues of the organism itself are concerned, and in process of degradation the latter split off water. In this sense we encounter the paradoxical phenomenon that fasting in part neutralizes the effect of water-withdrawal, and that, consequently, the animals live longer.

Consequently the pigeons that Nothwang fed on

dried peas survived on an average for $4\frac{1}{2}$ days, whereas the animals studied by Falk and Scheffer, that received much less pabulum, as well as the animals of Schuchardt, lived from 11 to 12 days.

Death occurred when about 22 per cent. of water had been lost; the existence of the animal may be said to be threatened as soon as the loss of water reaches approximately 11 per cent.

Landauer (33) studied the question from other points of view that interest us; his results form the basis of many of the conclusions arrived at by later authors.

Landauer, experimenting on dogs, arrived at the result that the urinary nitrogen excretion, *i.e.*, the destruction of albumen, is increased by thirsting. In his experiments the increased nitrogen excretion persisted even during an after-period (during which liquid was again ingested), and the author attributes this to a retention of nitrogen during the thirst period, and a subsequent flushing out of nitrogenous waste.

Landauer also paid attention to the CO_2-excretion during thirsting. However, he arrived at no positive conclusions and, moreover, employed methods that were not beyond criticism, as emphasized by Straub (34).

The destruction of albumen that Landauer found during the thirst-period was also found by Straub. The latter author fed dogs on air-dried meat powder and bacon. During the fore- and after-period the animals received water, but received none during the

main period of the experiment. In all of his investigations he found an increase of the urinary nitrogen during the period of thirsting, also an increase of the P_2O_5-excretion. The increased excretion of nitrogen continued during the first days of the after-period; the same applied to the P_2O_5-excretion.

Straub's investigations are particularly important, because he did not limit himself to a study of the albumen catabolism alone, but also made an exact investigation of the elimination of CO_2, a factor that has a very important bearing on the destruction of fat. *He found that the excretion of CO_2 via the skin and the lungs was not appreciably increased.*

In fact, when one compares the figures for CO_2 during the fore-, the main-, and the after-period, it will be found that during the days of thirsting the CO_2-excretion was slightly decreased.

The excretion of water through the skin and the lungs was found to be slightly, but distinctly, decreased.

The main result, therefore, of Straub's investigation is a corroboration of the fact that *the destruction of albumen is increased* during a period of water-withdrawal. Contrary to the findings of Landauer, on the other hand, Straub, employing better methods, could find no evidence to show that the withdrawal of liquids led to increased destruction of fat (no increase of the CO_2-production during the period of thirsting).

Almost simultaneously with the investigations of Straub appeared certain studies by Dennig (35); these

contained a mass of careful clinical observations that corroborated most of the findings of older authors. The studies were undertaken on human subjects that were subjected to such degrees of thirsting that their general health became seriously impaired and a pronounced distaste for solid food became apparent. Under these conditions the weight and measurements of the body rapidly decreased. The sphygmogram indicated decreased arterial tension. The specific gravity and the amount of dry residue of the serum became increased. The urinary water-output during the period of thirsting greatly exceeded the water-intake during this time, whereas during the fore- and after-periods the reverse was the case.[3] The temperature showed an inclination to rise.

The insensible perspiration decreased from day to day during the period of thirsting, and increased again during the after-period when drinking was resumed. During the thirst-period, and particularly during the first days of the after-period, Dennig discovered perversions of the nitrogen and the fat-absorption, particularly of the latter.

During the time when water was withheld and during the days immediately following (*i.e.*, during the first days of the after-period), *the excretion of nitrogen was relatively and absolutely greater* than during the fore-period. Dennig draws the following conclusion from this finding: "There is undoubtedly

[3] Compare also Jürgensen: "The Effects of the Schroth Treatment." Deutsch. Arch. f. Klin. Med. vol. i.

destruction of albumen, and a portion of the degradation products derived from this process are not flushed out until water-drinking is resumed."

In a second series of investigations performed on the same subject the effect of thirsting upon the destruction of albumen did not, by the way, become apparent, and Dennig attributes this to habituation.

In still another very exhaustive communication Dennig (35) reports on the effect of water-withdrawal, particularly on *obese subjects.* In general, the results corresponded to those reported above. It appeared, however, that fat persons could tolerate thirsting better. No disturbances of absorption were found in such subjects. The loss of albumen during the thirst period was considerably smaller than in lean subjects, occasionally almost *nil.*

Dennig expresses himself as follows in regard to the effect of thirsting upon metabolism: "The water that the organism gives off during the thirst-period must be replaced by dehydration of the tissues, in particular by *the combustion of fat* and *the destruction of albumen*"; in another place he emphasizes the fact that not all of the nitrogen that is excreted in increased quantity during the period of thirsting need be derived from the disassimilation of tissue-albumen, "for human adipose tissue, according to A. W. Volkmann, contains 0.45 per cent. of nitrogen, so that a large portion of the nitrogen that is excreted in excess, about 30 per cent., may be derived from the disassimilation of fat."

The last of the larger investigations that are concerned with the questions under discussion is the communication by Spiegler (36); here some of the details of the nitrogen-excretion during periods of thirsting are chiefly discussed.

In many of the experiments reported by the different authors the urinary nitrogen excretion was found to fall in the beginning of the thirst period and then gradually to rise to values that were above normal. In many instances, even, the increased nitrogen-excretion was not noted until the first day of the after-period. Thus, *e.g.*, in one investigation reported by Dennig, in which the N-intake and the absorption of the food remained constant, the urinary N-output assumed the following values:

Fore-Period	10	19.38
	11	19.98
	12	19.99
Main-Period	13	18.62
	14	17.32
	15	18.48
	16	18.96
	18	19.39
	19	19.62
After-Period	19	21.70
	20	22.06
	21	24.36
	22	19.53
	23	20.03
	24	20.00

Landauer interpreted the initial fall of the N-excretion during the thirst-period to signify that the destruction of albumen, while increased during this period, still

did not lead to an increased N-excretion, because the nitrogenous waste that was formed in excess was retained owing to the fact that too little water was available to readily flush it out of the system. We know, for instance, that normally a large excess of water will flush out a certain quantity of retained nitrogenous material from the tissues,—Meyer, Oppenheim, von Noorden, Neumann (37),—and thus lead to an increase of the urinary nitrogen.

Dennig interprets the fact that the highest values for the N-excretion are found in the first days of the after-period in the same way, and attributes this phenomenon to flushing out of retained nitrogenous waste. Straub, who in a previous publication[4] also advocated this view, expresses himself somewhat differently in the paper referred to above; here he maintains that the increased N-excretion during the days following the thirst-period must be attibuted to a continuation of the increased destruction of albumen, because, he argues, during these first days the organism is still partially dehydrated and must first replace the water that was lost during the period of water-withdrawal.

Spiegler is inclined to explain the drop in the N-excretion at the beginning of the thirst-period by assuming that the absorption of food is retarded. The striking fact that the highest values for nitrogen are found in the after-period he explains by a resumption of the absorptive function in the bowel and a resulting

[4] Zeitschrift für Biologie. 1899. Vol. xxxvii.

rapid assimilation of the food material accumulated in the gastro-enteric tract.

Spiegler arrived at these conclusions from short series of investigation with only one thirst-day. His views may be correct for such short periods, but their application to investigations extending over longer periods of time is doubtful and combatable. This is not, however, the place to argue the pros and cons of the different views held by all these investigators. It is probable that the course of the N-excretion during the period of thirsting is the resultant of the various factors enumerated above.

Spiegler has also furnished a contribution to the inquiry whether or not more fat than normal is destroyed during the thirsting period. He fed two dogs of the same litter, that were from 6 to 7 weeks old, with boiled meat. One dog was used as a control and received every morning, together with his meat or soon after eating it, all the water he wished to drink. The other dog never received any water with his meat, but only at noon or in the evening; at these times, however, too, in any desired quantity; this dog, one might say, therefore, was "Schweningering."

In the course of this investigation, that extended over three months, the difference in the weight of the two dogs, that originally was 960 g. in favor of the control-animal, rose to 2441, and Spiegler attributed this to a greater destruction of proper tissues on the part of the experiment-dog as compared to the control-dog. Spiegler declares himself justified in excluding

the possibility of a greater loss of water on the part of the first animal, and attributes the difference in weight to a greater destruction of albumen and probably also of fat, as the experiment-dog looked exceedingly thin and lean. In rebuttal of Straub's finding that the CO_2-excretion did not increase on withdrawal of water, Spiegler called attention to the possibility that a young, growing animal reacted differently to the withdrawal of water—as far as the destruction of fat is concerned—than an adult animal.

It is clear that this experiment is open to criticism on many counts and that it is unsuited to solve the various questions under discussion. In the first place, the difference of 970 g. in the weight of the two young dogs of the same litter is not insignificant, and one could readily imagine that the experiment-dog might have spontaneously failed to gain as much weight as the control-animal. In the second place, no information is given in the article in regard to the important question whether the absorption of the food was as good in the experiment-dog as in the control-dog.

We see, therefore, that the statements made by different investigators in regard to the increased destruction of fat in thirsting animals and human subjects are highly contradictory. One thing, however, is established, viz.: Very great restriction of liquids, leading to torturing thirst, is followed both in man and animals by an increased excretion of nitrogen. We regard this as a manifestation of *toxic*

tissue destruction. The toxins that are formed in process of metabolism are not properly eliminated, and are consequently retained in the tissues and poison the protoplasm of the cells. Consequently we witness an increased excretion of N and of P_2O_5, that becomes manifest either at once or later (dependent upon certain circulatory conditions and the eliminative powers of the kidneys) in the urine.

In order to produce this unquestionably dangerous and unfavorable influence upon albumen catabolism, it is necessary, however, to restrict the ingestion of liquids to a point that is far below the measure allowed obese subjects and others for therapeutic purposes. The water in the diet used in the clinical experiments of Jürgensen and Dennig amounted to only 300 to 500 c. c. Oertel never went below about 1 liter of water (including the water incorporated in solid and semi-solid articles of diet.) Practical experience extending over the intervening twenty years has definitely taught us in the meantime that one cannot and should not go below 1000 to 1200 c. c. of liquid (not including the water contained in the solid food) in reduction cures for obesity.

The results obtained in regard to the destruction of fats vary, as we have seen. The study of Landauer, performed with methods that are open to criticism, and the experiment of Spiegler, that is not free from ambiguity, seem to decide in favor of the theories of Oertel and Schweninger. The more exact series of investigations that Straub performed in animals seem

to decide against these theories. So far no experiments have been made in human subjects that can form the basis for scientifically accurate conclusions in regard to the effect of water-restriction upon metabolism.

We have attempted to approach this question by studying the respiratory interchange of gases in healthy and obese subjects. These studies will now be reported.

III. EXPERIMENTS BY THE AUTHORS

In order to study the intensity of oxidative processes in the organism, determinations of the oxygen consumption are, as a rule, performed; one is accustomed to consider the values obtained for the consumption of oxygen in a resting subject, early in the morning, before the ingestion of any food, as an index of the intensity of the oxidative processes in this individual. For, thanks to the investigations of Zuntz (38) and Magnus Levy (39), we know that the consumption of oxygen under these conditions is practically constant in the same individual. In our studies, therefore, the early morning values for the oxygen consumption were determined in a number of subjects—this was a fore-period during which the use of water was unrestricted; the same determinations were then performed in a main-period during which liquids were restricted, and again in an after-period during which liquids *ad libitum* were again permitted.

In order to exercise some control over these subjects, who were confined in different rooms, and in order to be certain that they did not exceed the quantity of liquid allowed them, the quantity, the specific gravity and the appearance of the urine, also the specific gravity of the blood and of the blood serum, were determined. Without entering into a detailed dis-

cussion and interpretation of the significance of the latter figures, I have simply entered them into the tables, because I believe that they present certain points of interest that are independent of the questions under discussion.

During the main- and middle-period of the experiment the amount of liquids was restricted. Sometimes the withdrawal of liquids was reinforced by the administration of electric-light baths that produced abundant loss of water by profuse sweating.

The water contained in the solids of the diet was not included in the calculation, because otherwise the analytic part of the investigation would have been unnecessarily increased out of all proportion to any possible value it might have possessed. Instead, great care was exercised to maintain uniformity of diet, both quantitatively and qualitatively throughout the whole course of the experiment; particular directions were also given to have the food prepared in the same way, so that the water content of the various dishes remained approximately constant.

In several cases, *e.g.*, in cases 1, 2, 15, *the patients did not take the whole quantity of weighed solid food prescribed* that, in preliminary studies, had been found to correspond to their individual tastes and requirements. Consequently, the total quantity of water was still more limited in these cases than was shown by the determination of the actual amount of liquids consumed. It is interesting to note in this connection that *thirsting led to an involuntary and distinct re-*

striction of the total amount of food ingested, an observation that is of the greatest importance in interpreting the reduction of obesity that follows the restriction of liquids.

In nearly all of the cases the loss of weight, the quantity, the specific gravity and the appearance of the urine, as well as the concentration of the blood, showed that a condition of thirst really existed. The withdrawal of liquids was in no case carried to excess, if for no other reason than the one that such extreme reductions in the fluid-intake are not employed in practice in reduction cures for obesity.

The determination of the interchange of gases was performed with the Zuntz-Geppert apparatus, an apparatus that has already aided us in discovering so many truths in regard to the physiology and the pathology of the gas-metabolism of the organism. The short duration of each experiment (20-45 minutes), it is true, rendered it necessary to exercise considerable care in interpreting the results obtained; the great facility, however, with which a large number of single determinations that controlled and supplemented each other could be performed in the same individual fully compensated for this defect.

All the gas-figures were reduced to 0°, 760 mm. barometric pressure, and dryness.

The determinations of the specific gravity of the blood were performed with the pyknometer and were always made at 11 A. M.

In order not to extend and complicate the tables too

much, the quantity of the urine and its specific gravity are only given on those days on which determinations of the respiratory interchange of gases were made.

Particular care was taken to accustom the patients to the technique of the experiments before the proper investigation, *i.e.*, the "fore-period" was begun. We did not begin the "fore-period" until the patients had learned to breathe quietly and regularly, without performing any voluntary muscle-movements, as long as they were in the apparatus.

In the text of this dissertation we are giving only the average values obtained in the different periods. The numerical details will all be found in the exhaustive tables appended to this article.

All the patients gave their explicit consent to these experiments.

(*a*) *Experiments in Subjects that Were not Obese*

CASE I.—Schm., age twenty-two, servant girl. Chlorosis of a pasty type; fairly well developed fatty layer. Weight on admission 54 kg., height 1.48 m.

The patient during the fore-period, without restriction of liquids, imbibed from 1500 to 1700 c. c. During the period of thirsting this quantity was gradually reduced to 300 c. c., and, in addition, an electric-light bath was administered on three days of this period.

During the period of restriction of liquids the appetite remained good; thirst was very severe.

The concentration and the specific gravity of the

urine were greatly increased. Despite the small intake of fluids, the girl's weight was not greatly decreased. The greatest difference observed during the period of thirsting was a decrease of 1.1 kg. as compared with her weight at the beginning of the thirst period.

The withdrawal of blood from a vein was refused.

The average consumption of oxygen during the fore-period of four days was *221.8* c. c. a minute, during the thirst-period of twenty-two days *206.6* c. c., during the after-period of twenty days *204.3* c. c.

We are not inclined to attach any importance to the difference observed between the fore- and the main-period.

As already mentioned, we took particular pains not to begin the proper "fore-period" until a certain constancy in values for the oxygen-consumption in the morning before breakfast had been attained. This point could occasionally not be determined until the experiment was already under way, and sometimes the values for the oxygen-consumption became unavoidably smaller during the experiment itself. In order to eliminate the error introduced in this way, the "after-period" was prolonged.

In this particular case so much at least was determined, viz.: that *the values for the respiratory interchange of gases, i.e., for the total oxygen-metabolism of the organism, were not increased during the period of thirsting.*

During menstruation, that occurred during the

period of thirsting, no particular fluctuations in the values for the oxygen-consumption were noted.

RECORD OF THE CONSUMPTION OF OXYGEN

	Number of Determinations.	Average Values.	Maximum.	Minimum.	Duration of Each Period, in Days.
Fore-period	5	221.8	237	200	5
Main-period	14	206.6	216	191	22
After-period	6	204.3	210	196	20

CASE 2.—O. Sch., age eighteen; chlorosis. No treatment so far. The patient from October 23 to November 19, inclusive, received liquids *ad libitum*, the total daily intake fluctuating from 1250 to 1500 c. c.

The period of restriction of liquids lasted from October 12 to October 20, inclusive. The patient suffered severely from the subjective manifestations of thirst, notwithstanding the fact that the restrictions imposed upon her were not especially severe. The ingestion of solid food was a little, but not markedly, decreased during this period of thirsting.

During the period of restriction of liquids the specific gravity of the blood rose from an average of 1036.3 to 1043.55, that of the serum from 1028.8 to 1031.1.

It is interesting to note that the specific gravity of the blood and the serum remained at the same height during the after-period. This recalls the observations of von Noorden (40) and Romberg (41), who showed

that chlorotic patients often deposit too much water in their tissues. It is useful in such cases to precede the specific iron-treatment with a course of water-restriction.

The consumption of oxygen in this case was decreased a little after the fore-period—for the same reasons, apparently, that were discussed under Case 1—but the values did not become lower than those obtained in single determinations during the three weeks of the after-period.

RECORD OF THE CONSUMPTION OF OXYGEN

	Number of Determinations.	Average Values.	Maximum.	Minimum.	Duration of Each Period, in Days.
Fore-period	7	242.3	250	235	17
Thirst-period	9	233.5	250	227	8
After-period	4	234.7	243	225	19

	Specific Gravity of Blood.	Specific Gravity of Serum.	Number of Erythrocytes.	Hæmoglobin, after Gowers. Per Cent.
During the Fore-period	1036.0 1036.6	1028.8 1028.8	3,040,000	45
End of Main-period	1043.6 1044.5	1031.0 1031.2	3,590,000	55
End of After-period	1043.6	1031.2 1031.0		

There is no evidence whatsoever of an increase in the consumption of oxygen during the period of thirsting.

During menstruation, by the way, the values obtained corresponded exactly to the average values.

During the period of thirsting the patient's weight fell from 70.2 kg. to 68.3 kg., but already on the fourth day of the after-period she had regained her original weight.

CASE 3.—A. S., age nineteen, chlorosis, also no previous treatment; weight 49 kg., height 1.58 m. Course very similar to previous cases.

After a fore-period of 6 days (March 16 to March 22) came a main-period of 15 days (April 23 to May 8, inclusive); severe sensation of thirst, moderate reduction in the intake of solids during this period.

Loss of weight during the thirsting period from 48.9 kg. to 47.0. During the after-period of three weeks the patient regained her original weight (48.5 kg.).

RECORD OF THE CONSUMPTION OF OXYGEN

	Number of Determinations.	Average Values.	Maximum.	Minimum.	Duration of Each Period, in Days.
Fore-period	5	217.5	226	199	5
Thirst-period	11	205.6	214	195	17
After-period	11	202.6	217	194	22

BLOOD FINDINGS

	Specific Gravity of Blood.	Specific Gravity of Serum.	Number of Erythrocytes.	Hæmoglobin, after Gowers. Per Cent.
During the Fore-period........	1044.2 1043.4	1028.8 1028.2	3,988,000	32
End of Main-period...........	1048.3 1049.3	1030.6 1031.0	4,112,000	40
End of After-period...........				

CASE 4.—Dora L., age twenty-two, anæmia. Moderately well-nourished subject; weight 53.7 kg., height 1.53 m. The fore-period lasts from July 12 to 18 inclusive, the main-period from July 21 to August 3, inclusive. The intake of solid food was decreased during the period of thirsting. The body-weight decreased 2.7 kg., the specific gravity of the blood and serum were markedly increased. During the after-period the specific gravity of the blood remained as high as during the main-period, the specific gravity of the serum, however, was decreased, but still remained higher than it had been at the beginning of the experiment.

During the thirsting-period a few remarkably low values for the oxygen consumption were found in this patient (*e.g.*, on July 30 and 31). This discrepancy is so striking that we hesitate to include these figures

as completely valid in our calculations, notwithstanding the fact that the experiment was each time carefully revised and no sources of error whatsoever were discovered.

BLOOD FINDINGS

	Specific Gravity of the Blood.	Specific Gravity of the Serum.
During the Fore-period	1046.3 1046.1	1027.1 1027.5
End of the Thirst-period	1056.8 1056.3	1033.5 1033.5
End of the After-period	1056.8 1052.4	1029.7 1029.9

RECORD OF THE CONSUMPTION OF OXYGEN

	Number of Determinations.	Average Values.	Maximum.	Minimum.	Duration of Each Period, in Days.
Fore-period	8	209.4	221.1	199.6	7
Thirst-period	11	196.6	206.9	180.4	15
After-period	11	202.7	206.9	196.6	22

CASE 5.—Kath. F., age twenty-six; nephritis chron., without œdema, existing for one and one-half years, occurring after an attack of angina, with albuminuria $\frac{1}{4}$ to $\frac{1}{2}$ pro mille, few casts; no change about the heart and arteries. Small (1.5 m.) but strong girl, fairly well nourished; weight 50.6 kg.

The oxygen-consumption, taking the average of ten determinations made during the fore-period, was 203.7 c. c. a minute; the figure obtained on October 17 was for unknown reasons abnormally high, and we have neglected it in calculating the above average.

During the main-period, the patient being very willing to help us, it was possible to reduce the liquid-intake to 300 c. c. a day. During this period of thirsting the appetite and the intake of solids were much reduced. The weight of the patient during this time fell from 50.5 to 48.2 kg. This loss, however, was rapidly regained during the first six days of the after-period.

The specific gravity of the blood and the serum was high in this patient before the withdrawal of liquids was begun, *i.e.*, 1062.9 and 1031.3, on an average. These figures during the period of thirsting rose to 1066.4 and 1034.8.

In this case, too, great restriction of fluids failed to produce any increase in the oxidative processes.

BLOOD FINDINGS

	Specific Gravity of the Blood	Specific Gravity of the Serum
During the Fore-period	1062.9 1062.9	1030.8 1031.8
End of Thirst-period	1066.5 1066.3	1034.8 1034.8

RECORD OF THE CONSUMPTION OF OXYGEN

	Number of Determinations	Average Values	Maximum	Minimum	Duration of Each Period in Days
Fore-period	10	203.7	231.0	182.0	12
Thirst-period	8	196.5	202.6	186.3	8
After-period	4	202.9	209.3	190.9	6

(*b*) *Experiments in Obese Subjects*

CASE 6.—J. L., young girl of eighteen years, parents obese, has been very fat since her thirteenth year; large, robust frame; height 1.685 m.; weight 98 kg.

The patient, who was perfectly healthy, happened to be staying in the hospital with her mother, who was suffering from diabetes. No notes in regard to the quantity of her urine or the specific gravity of her blood were made. The patient suffered greatly from thirst. The main-period of thirsting followed a fore-period lasting from July 29 to August 3, and extended from August 4 to August 12. The amount of fluid-intake was at once reduced to 300 c. c. a day, and kept there. An after-period could unfortunately not be carried through. During the fore-period the average value for the oxygen consumption was 262.5 a minute, during the main-period 249.5 a minute. The figures obtained on August 7 and 8 are strikingly low. In

this case, it may well be that the better control of voluntary muscle-movements, that the patient acquired as she became accustomed to the technique of the experiment, contributed somewhat to the progressive decrease in the values for the oxygen-consumption. However, it is certain that thirsting did not produce any increase of the oxygen-consumption.

The following table represents a summary of the figures obtained:

	Number of Determinations.	Average Values.	Maximum.	Minimum.	Duration of Each Period, in Days.
Fore-period	7	262.5	272.6	247.5	7
Main-period	5	249.5	274.3	229.8	5

Case 7.—R. J., young girl of sixteen from a neuropathic family, no member of which was corpulent. Patient very fat since early childhood, and became relatively still more obese at thirteen and one-half years, after the onset of menstruation. It is stated that she never ate excessively, but, on the contrary, that she was, if anything, very moderate in her eating; it was also stated by the girl and her parents that she had plenty of exercise by taking long walks and helping with domestic duties. During the last few years she suffered from a variety of nervous disorders, *i.e.*, vertigo, headache, insomnia. In addition a tendency to furunculosis was reported. Aside from her obesity

the patient showed nothing abnormal; all the internal organs were sound; occasionally, however, the lips appeared slightly cyanotic. She was 1.63 m. tall, and weighed 72 kg.

The circumference	of the	neck was	33.5	cm.
"	" "	upper arm was	26.0	"
"	" "	abdomen was	98.5	"
"	" "	middle of the thigh was	51.0	"
"	" "	calf was	38.0	"

In the course of this observation it was found that the patient represented a case of genuine constitutional obesity. The patient therefore received the following diet from March 18 to 26:

At 8 o'clock: ¼ liter of milk; ½ roll.
" 10 " 100 g. of orange.
" 12 " 1 apple.
Noon: 200 g. of potatoes, with 30 g. of butter.
Green vegetables prepared without flour and with 20 g. of butter; 100 g. of apple sauce.
At 4 o'clock: ¼ liter of milk, ½ roll.
" 6 " 100 g. of orange.
" 8 " ½ roll, 1 pear.
" 9 " ¼ liter of milk.

This diet contains about 1300 calories (equal about 18 cal. pro kilo.). The patient, who was carefully watched, increased her weight during nine days of this diet, from 71.4 to 71.9 kg. She was out of bed during the daytime and exercised considerably by taking walks through the garden. During a second period of observation her weight remained constant on a six-days' diet consisting of 2½ liters of milk and 200 g. of Graham bread (1900 calories = 26 calories pro kilo.).

After these preliminary facts had been determined, exact metabolic studies were undertaken with this

patient. Whereas in all the preceding cases the diet was uniform but not regulated in every detail, with the exception of the amount of liquid allowed, the diet in this case was mathematically prescribed in order that some information in regard to her nitrogen-metabolism might be obtained.

The patient, during the fore-period that extended from December 19 to 29, received the following diet:

One liter of milk, 500 g. of coffee (extract made from 40 g. of coffee), 400 g. of bouillon, 100 g. of meat, 150 g. of bread, 1 egg, 80 g. of butter, 30 g. of sugar, 200 g. apple sauce, and 6 g. of nutrose (this food contained about 1900 calories and about 14 g. of nitrogen). The nutrose was given in order to bring the N of the food up to a certain value corresponding to that demanded by a previous determination of the N-metabolism in this case.

On this diet the patient maintained her weight, but retained considerable nitrogen.

During the main-period, that lasted from December 29, 1901, to January 7, 1902, bouillon and coffee were at first omitted from the diet, *i.e.*, about 900 c. c. of fluid; from January 2 to 7 the 1 liter of milk, that now represented the whole fluid-intake, was reduced to ½ a liter. The nitrogen omitted by the withdrawal of the coffee and the bouillon was replaced by an equivalent quantity of meat-extract (6 g.), the nitrogen of the milk, that was withheld, replaced by an equivalent quantity of nutrose (19 g.), and the fat of the milk by butter (20 g.).

It was impossible to carry the restriction of liquids farther in this very sensitive patient. Even when we proceeded as above, she complained of very distressing thirst; at the same time the appetite was lost, so that the prescribed diet could only be eaten with reluctance.

The patient, however, lived up to her régime with great energy, because she was determined to do everything possible to reduce her fat. The table of Case 7 gives all the information in regard to the albumen and gas-metabolism of this patient.

This table shows that during the fore-period N was still retained, an average of 1.8 g. a day, while the weight of the patient remained essentially the same. The quantity of urine was abundant, but remained below the liquid-intake.

During the main-period the N-equilibrium was upset, in the sense that more N was excreted in the urine than was ingested; this did not render the N-balance distinctly negative, but it indicated an increased destruction of body-albumen. The more pronounced and the more continued the restriction of liquids, the more did this become apparent; thus from January 4 on there was nitrogen-equilibrium, whereas prior to this date N was retained. The quantity of urine from this time on also rapidly decreased, the urine became more concentrated, and the output of water in the urine exceeded the intake of water by mouth.

This investigation, therefore, reveals the characteristic increase of albumen destruction during the period

of thirsting. It is probable that an after-period with better flushing of the tissues would have shown a still greater increase of the urinary N-excretion; unfortunately this patient, whose appetite had become seriously impaired by the prolonged thirsting, could not in fairness be requested to undergo the further inconvenience of an after-period of observation.

We now come to the consumption of oxygen.

An increased oxygen-consumption could, at all events, not be determined. The average values for the period of thirsting and the after-period (the latter, for reasons outlined above, more important than the fore-period) almost correspond, whereas a decrease of the average values, as compared to the fore-period, is noted.

It is important to emphasize that no appreciable loss of weight occurred during the period of thirsting. Unfortunately the insensible perspiration was not determined in this experiment, so that no exact analysis of this factor can be undertaken in this place.

RECORD OF THE CONSUMPTION OF OXYGEN

	Number of Determinations.	Average Values.	Maximum.	Minimum	Duration of Period in Days
Fore-period	8	214.1	221.8	203.5	13
Thirst-period	9	199.9	207.5	186.8	9
After-period	4	199.1	206.8	193.1	10

(c) Review of Investigations

In summing up we may say that in none of the reported experiments during the thirst-period was there shown an increased consumption of oxygen, measured always when the stomach was empty.

There is indeed reason for raising the question whether the increased destruction of albumen, that has been frequently observed and that takes place in many individuals at least, does not cause an increase in the amount of the oxygen-consumption. One might in fact expect this; but this criterion fails, and we can only infer that in the proteid metabolism of thirsting persons there is merely a perversion of the process, since with the same total catabolism there is relatively a less decomposition of fat.

By restricting liquids, therefore, in a subject whose solid diet remains the same, we cause a loss of water, occasionally a loss of albumen, but no loss of fat. If at the same time some loss of fat does occur, *this cannot be considered one of the primary consequences of thirsting, in the sense of Oertel and Schweninger,* but it must be regarded as dependent on certain concomitant factors and influences, chief among them, undoubtedly, the loss of appetite that occurs when the patients are made to suffer thirst.

IV. CONCLUSIONS

The preceding discussion has established that the restriction of liquids is inevitably followed by certain consequences, viz.:

1. The stomach is relieved of much work, and the pressure exercised upon its walls is reduced.

2. The total labor performed by the circulatory apparatus is decreased, and the heart is spared.

3. The fluids of the body become more concentrated.

4. The body-weight is decreased as a result of the dehydration of the blood and tissues.

5. The appetite is reduced.

6. The destruction of albumin is increased (only, however, if the restriction of water is carried very far).

With the exception of the last-named effect of thirsting, that appears to an appreciable degree only in very greatly exaggerated restriction of liquids, all these factors can be utilized for therapeutic purposes. They actually explain all the good therapeutic results that have ever been obtained from the restriction of water.

7. On the other hand, the claim that water-restriction increases and accelerates the combustive processes going on in the organism, and, in particular, the destruction of fat, was not borne out by our experiments. Our investigations are the only ones that have

so far been carried out in human subjects; in our opinion, however, they are absolutely conclusive, because no serious objections can be raised against our methods or the general plan and arrangement of our various experiments.

V. THERAPEUTIC CONSIDERATIONS

There remain to be discussed certain therapeutic aspects of the question; above all it is interesting to determine in what disorders the restriction of liquids may be considered a rational procedure. Some of the most important points of this inquiry have already been discussed in the first chapter, so that it will be unnecessary to again argue for the restriction of liquids in certain disorders of the cardio-vascular apparatus, the kidneys, and the stomach.

(a) *The Restriction of Liquids in the Treatment of Obesity*

The restriction of liquids in obesity must above all be carefully considered; we must see whether one is ever justified in ordering this restriction, notwithstanding the fact that the investigations described in this monograph show conclusively that one can no longer maintain that the restriction of liquids produces an increase in the intensity of oxydative processes and, in particular, in the combustion of fat.

1. The heart, in obese subjects, is always in some danger of overtaxation—less so in strong, muscular individuals than in weakly persons. A certain limited restriction of liquids (making the total liquid-intake during 24 hours about 1500 c. c.—including everything that flows) is advisable, if for no other reason

than that it excludes at least *one* of the influences that may act deleteriously upon the heart. As we know from experience that obese subjects very easily acquire the habit of imbibing large quantities of liquids, it is absolutely essential that the physician should inquire into the amount of fluid-intake in each case; only in this way can he advise some restriction of liquids with a view to exercising an intelligent prophylaxis even before the heart or arteries show any morbid symptoms. This procedure is still more important in cases in which the heart is already weakened. We agree with numerous authors, who have expressed themselves in this sense since Oertel's publications, that signs of a weakened heart-action, *e.g.*, dyspnœa, mild stenocardiac disturbances, irregularity of the pulse, slight degrees of cardiac dilatation, can frequently be favorably influenced, in obese subjects, by a certain amount of water restriction, even though no actual loss of fat occurs.

In the case of fat people the same rules apply, as far as the heart is concerned, as in the case of sufferers from cardiac disorders; and the value of water-restriction in the latter class of patients has been fully discussed in the clinical introduction to this article (see above).

2. In contradistinction to the untenable theories of Oertel and Schweninger, we do not consider the concentration of the blood and tissue-juices to be an important factor in the destruction of body-fat. One good result may, however, occasionally develop from

this effect, viz., that sweating decreases when the body-fluids become more concentrated, so that the disagreeable hyperhydrosis of obese subjects is often rapidly and favorably influenced by careful and persistent restriction of the liquid-intake.

3. We know from experimental and clinical experience that precisely in the beginning of a course of thirsting relatively much water is eliminated from the body. The great losses of weight, amounting to several kilograms, that are often seen during the first week of a reduction cure with restriction of liquids, are usually attributable to the loss of water. From a psychological point of view, as von Noorden (23) has emphasized, this large initial decrease in weight is an important factor. It gains at once the confidence of the patients, who have often sought in vain to decrease their flesh by following other plans; if the patients find that they begin to lose flesh after a few short days of this régime, they are naturally much more willing to cheerfully and energetically undergo the necessary privations that are to follow. The physician should never forget, however, that the loss of weight obtained in this way is not due to loss of fat, but to loss of water.

4. The effect of the restriction of liquids upon the appetite is of the greatest importance. In this case the reduction in the total liquid-intake is less important than the withdrawal of liquids during meals. The effect of the latter regulation, as von Noorden (23) has shown in several cases, varies greatly in dif-

ferent subjects. Some people are not influenced at all by stopping water-drinking during meals, and eat as much and with the same relish as before; some even develop a greater appetite and eat more. Under these circumstances no loss of flesh can, of course, be expected. Others, in the beginning, suffer some loss of appetite and lose a little flesh, but they soon become accustomed to the new order of living, so that no appreciable effect upon assimilation and catabolism is produced. Von Noorden, in his monograph, quoted a number of cases of this kind, and we have, in the meantime, amplified and corroborated his findings; many physicians, moreover, know from their own experience that nothing permanent is attained in many obese subjects by the restriction of liquids. On the other hand, there are many persons—both healthy and sick—who always eat less when the fluid-intake is reduced, and who sooner or later lose flesh on this régime. Habit plays a large rôle in these cases. It is probably more than mere coincidence that both Oertel and Schweninger, in their first observations, that are beyond reproach and fully authenticated, encountered only subjects who invariably began to lose flesh as soon as the liquids were restricted, and, above all, when the drinking of water during meals was prohibited. Both these authors, as well as Lorenzen, collected their material in Bavaria, a country in which, from time immemorial, very much more fluid (beer) is taken during meals than in any other country in the world. That solid food could be taken

without drinking was something altogether new, something they were not accustomed to, and that many of the patients of the above-named authors considered unnatural; consequently one need not be surprised to find that they voluntarily ate less solid food as soon as drinking during meals was interdicted. However that may have been, the fact remains that many persons eat considerably less when they are not allowed to drink *ad libitum* at the same time. In our own experience we have seen this effect of thirsting especially in children, in heart cases, in sufferers from renal diseases, and by no means least pronounced in obese subjects, especially in that form of obesity that has been symptomatically designated by the name of "plethoric obesity." In patients with so-called "anæmic obesity" a spontaneous craving for abundant liquid is on the other hand frequently absent, and the restriction of liquids by order of the physician generally exercises no effect upon the amount of solid food ingested, nor does it cause a loss of fat.

We see, therefore, that the restriction of liquids is a therapeutic weapon in reduction cures that sometimes is dull and treacherous and at other times sharp and effective. A physician who has enjoyed much experience in such cases will in the majority of instances be able to predict correctly whether or not this weapon will be useful and successful; but even the most experienced practician may be misled, and he, too, like the inexperienced, is forced to carefully study each individual case before he can decide whether the

restriction of liquids is going to bring about the desired result or whether it is going to be without effect.

Unless forced to do so by special reasons (see above, 1-3) we do not employ the restriction of liquids extensively in our clinic—following in this respect the ideas enunciated by von Noorden in previous publications; nevertheless the therapeutic results we obtain in obesity are as good and as uniform, if not more so, than those obtained anywhere else.

When the heart is to be considered (see above), it is true, we do not permit more than 3/2 liters of liquids. This includes everything that flows, whereas the water contained in solid articles of diet is not considered. Only if large quantities of fresh fruit are given, that consists of about 90 per cent. of water, do we reduce the liquids still more. It is hardly necessary, however, to particularly order this further restriction, because the patients of their own account reduce the amount of beverages when they eat much fruit. If the restriction of liquids is carried no farther (maximum permitted = 3/2 liters), and if attention is chiefly given to a regulation of the caloric values of the solid ingesta, then results are seen in reduction cures for obesity, that yield a gradual loss of flesh without any feeling of discomfort or deprivation on the part of the patient; the reduction in the weight of cases treated in this way is not very rapid, but it is sure to occur gradually. In the average case the further restriction of liquids is, to say the least, superfluous; if it is

imposed at all it should not be done because it is customary to do so, or because certain routine methods of treatment require it, but because definite indications for this practice are found to exist. Otherwise the patients are subjected to unnecessary torture.

(*b*) *The Restriction of Liquids in Chlorosis*

In some of the cases reported above it was found incidentally that in chlorotic girls the restriction of liquids caused a considerable increase in the specific gravity of the blood and serum; the percentage of hemoglobin and the number of red-blood corpuscles also rose, although not to the same degree. After the termination of the period of water-restriction these values remained at the same level, although abundant water drinking was again permitted. This finding recalls the discovery that von Noorden (40), and soon after him Romberg (41), announced, viz.: that in chlorotic subjects the water percentage in the tissues is high, and that the occurrence of an abundant diuresis with loss of much water is to be welcomed as an early sign of improvement. One is further reminded of the fact that certain other methods have been advised in the treatment of chlorosis that lead to a withdrawal of fluids from the body, viz.: blood-letting, combined with diaphoretic measures. There is some diversity of opinions in regard to the value of these methods. On the one hand we have very favorable, even enthusiastic, reports—Dyes, Schubert, Dehio (42); on the other skepticism—Scholz, Künne, Paul

Schmidt (43). Our personal experience with blood-letting and diaphoresis in chlorosis is limited. We failed to see that the results obtained were sufficiently favorable, as compared to the great inconveniences of the method and the discomfort that the patients are made to suffer, to warrant its adoption. For this reason this form of treatment was soon abandoned in our clinic.

One would undoubtedly have gained a clearer insight into the value of this treatment if a more careful study of individual peculiarities had been made and if the exact stage of the disease had been more carefully considered by the various observers who have reported on this method. As von Noorden has pointed out, not every case of chlorosis is hydræmic, *i.e.*, the tissues are not overloaded with water. Moreover, the different authors who have written on bleeding, with diaphoresis, in chlorosis fail to inform us whether or not they attempted to prevent a rapid replacement of the water by restricting the liquid-intake.

It may be considered established that blood-letting at rare intervals may stimulate blood-formation in chlorotic subjects, and may in this way constitute the beginning of improvement (von Noorden [40]). It is, to say the least, doubtful whether diaphoretic measures, that are so popular in this day of physical therapy, are capable of exercising the same influence. Much that is written on the subject is vain hypothesis and unproved conjecture, but by no means physio-

logical truth. We do not want to deny at the same time that diaphoretic measures may not be of some benefit in chlorosis; we merely maintain that so far no explanation has been forthcoming for this phenomenon. We are particularly disinclined to deny the favorable general effect of diaphoretic measures in chlorosis, because we have found that the restriction of liquids to $3/2$ or $4/2$ liters a day, that acts in a similar manner as diaphoresis, exercises an excellent therapeutic effect in chlorosis and renders subsequent iron-therapy more effective. In favorable cases a mighty diuresis is seen during the period of water-restriction, so that the water-output exceeds the water-intake, just as von Noorden had previously described it. At the same time the patients' appetite and *their muscular vigor* increase in an extraordinary manner. On the other hand, this moderate restriction of liquids (to $1\frac{1}{2}$ to 2 liters) never exercises any appreciable effect upon *the percentage of hemoglobin.* Even if the restriction of liquids is carried still further (to less than 1 liter) the effect upon the hemoglobin percentage is only insignificant (see above).

We maintain that wise moderation in water-drinking is altogether rational in chlorosis, and that the same results are obtained therefrom in practice as from diaphoretic procedures that are much more severe. If one is unduly prejudiced in favor of diaphoresis, then one should at least support the advantage gained by restricting the liquid-intake to a certain degree. Unless this be done the one advantage that

seems important to us (see von Noorden, Romberg), viz.: the dehydration of the organism, will not be gained.

(*c*) *The Restriction of Liquids in Cirrhosis of the Liver*

We occupy the same standpoint in regard to the effect of diaphoretic treatment upon ascites due to hepatic cirrhosis as Leichtenstern, Matthes, H. Strauss (44), viz.: that as a rule the ascites does not permanently improve. We say "as a rule," for there can be no doubt that some cases derive extraordinary benefits from this treatment. Such isolated cases have recently been utilized by adherents of the "Naturheilmethode" (Nature's cure) for purposes of propaganda, and have been advanced as examples to show that puncture of the abdomen and Talma's operation (an operation, it is true, that has not so far altogether vindicated the claims of its advocates) are not to be recommended. Energetic diaphoretic, *i.e.,* dehydrating, treatment of ascites is by no means so far removed from scientific medicine as the voices that clamor from the camp of the water-doctors would have us believe. One of the warmest advocates of this treatment was Carl Gerhardt, who used to emphasize again and again in his clinical lectures that many a puncture of the abdomen for ascites is rendered superfluous by diaphoretic treatment. He advised, in particular, to sweat the patient daily for two to three weeks, in order to prevent the reaccumulation of water in the abdominal cavity. Later von Noorden in the General

Hospital in Frankfort modified this method in such a way that in addition to employing diaphoretic measures the amount of liquids was restricted, or the latter plan alone was adopted. We have observed in a limited number of cases—too small a number, it is true, to justify us in drawing final conclusions—that continued restriction of liquids (to about 1 to 1½ liters a day) caused a disappearance of the ascites, without subsequent recurrence. The case that was studied for the longest period was that of a merchant of fifty years who was punctured twice, and then refused a third puncture. He conscientiously followed the advice not to drink more than 1 liter of fluid a day for two years. At the expiration of the first six weeks he was quite free from ascites, nor was there any recurrence during the ensuing seven years, even though the patient during this period imposed no restrictions in regard to water-drinking upon himself.

(*d*) *The Restriction of Liquids in Hemorrhages*

The attempt to produce concentration of the blood in cases of hemorrhage, and hence greater coagulability, has often been made; on the same principle is the prescription of powdered salt and strong salt solutions in hemoptosis. Diaphoretic means are counterindicated in pulmonary hemorrhages, and have never become popular in hemorrhages of the digestive organs. The absolute withdrawal of liquids in such cases is more conservative than sweating, and at least equally rapid in effecting the result. We have repeat-

edly insisted upon the complete withdrawal of liquids (and in gastric or intestinal hemorrhages, of course, also of all food) for from three to five days, and we can recommend this apparently cruel, but in reality very useful and readily borne procedure, with a clear conscience. In view of the great danger to life, or, at the very least, of long-lasting weakness from repeated hemorrhage, thirsting (or thirsting and fasting) for several days is often to be considered as decidedly the lesser evil.

In the clinical and historical introduction to this article, and in the paragraphs on "Therapeutic Conclusions," a variety of maladies have been enumerated that can be benefited by more or less rigid restriction of the liquid-intake. Our disquisition is by no means, however, to be interpreted as signifying that this method of treatment is to be carried out schematically and in a routine manner in all of these conditions. One should never forget that the restriction of liquids is no indifferent procedure, but on the contrary one that often exercises a most profound influence upon the general nutrition of the body; so that the physician before ordering a restriction of the liquid-intake should always realize the great responsibility he is assuming and carefully weigh all the circumstances in each individual case. Applied correctly and within wise limits the method of restriction, however, is as important as, under certain other conditions, the opposite method of flooding the organism with large quantities of liquid.

TABLE I (TO CASE I)

Date	Quantity of Urine	Specific Gravity of the Urine	Body Weight in Kg.	Oxygen Consumption per Minute in cc.	Ingestion of Liquids	
6.	—	—	54.0	213	1500	
7.	—	—	—	200	1400	
8.	1000	1014	—	237	1500	Fore-Period. Average Consumption of Oxygen in 5 tests=221.8 cc.
9.	1800	1014	—	222.5	1100	
10.	1800	1012	—	237	1200	
11.	1200	1012	53.8	—	800	
12.	800	1020	—	207	375	
13.	800	1022	53.5	213	500	
14.	400	1028	53.2	209	500	
15.	600	1026	53.3	209	500	
16.	450	1026	53.5	207	400	
17.	550	1025	53.2	—	400	
18.	450	1026	53	202	400	
19.	600	1026	53	202	400	
20.	550	1025	53	203	400	
21.	750	1023	53.2	—	400	
22.	675	1022	53.2	212	400	Light Bath — Thirst-Period. Average Consumption of Oxygen in 14 Tests=206.6 cc.
23.	420	1026	52.5	—	400	Light Bath
24.	600	1026	52.0	205	400	
25.	500	1028	52.3	194	400	Light Bath
26.	630	1025	52.5	191	400	From IV 26 to 28 IV Menstruation
27.	600	1024	52.7	—	400	
28.	560	1025	53.1	207	300	
29.	600	1021	53.4	—	300	
30.	590	1022	53.4	207	300	
1. V.	600	1025	53.1	—	400	
2.	800	1025	52.7	216	500	
3.	800	1010	53.2	—	1100	
4.	1000	1010	52.7	203	2000	
5.	1000	1010	53.4	—	2000	
6.	1700	1014	53.7	210	1500	
7.	1900	1014	—	—	1800	After-Period. Average Consumption of Oxygen in 6 Tests=204.3 cc.
9.	1900	1010	—	—	2000	
15.	2200	1010	—	200	2500	
22.	1700	1020	—	196	2000	
23.	—	—	—	210	1800	

TABLE II (TO CASE II)

Date	Quantity of Urine	Specific Gravity	Weight in Kg.	Oxygen Consumption per minute	Density of the Blood	Density of the Serum	Erythrocytes E Hæmoglobin	Ingestion of Liquids	
23. X.	1200	1015	—	235	—	—	—	—	Average of 7 Tests = 242.3 cc.
27.	2000	1010	70.9	236	—	—	—	—	
4. XI.	1400	1012	—	242	—	—	—	1500	
5.	1200	1015	—	250	—	—	—	1500	
7.	900	1015	—	243	—	—	—	1000	
9.	1100	1015	—	243	α=1036.0 β=1036.6	α=1028.8 β=1028.8	E=3040000 H = 45 %	1250	
11.	1050	1012	70.2	247	—	—	—	1250	
12.	750	1022	70.0	250	—	—	—	750	Average of 9 Tests = 233.5 cc.
13.	900	1025	69.8	229	—	—	—	500	
14.	850	1030	69.5	236	—	—	—	500	
15.	780	1030	69.3	230	—	—	—	500	
16.	700	1028	69.0	237	—	—	—	500	
17.	900	1028	69.2	228	—	—	—	500	
18.	600	1030	68.7	237	—	—	—	400	
19.	650	1028	68.3	228	—	—	—	400	
20.	—	—	68.3	227	α=1043.6 β=1044.5	α=1031.0 β=1031.2	E=3590000 H = 55 %	—	
22.	1500	1010	—	225	—	—	—	1650	From 22-26 XI Menstruation; Average of 4 Tests = 234.7 cc.
26.	1200	1017	70.8	231	—	—	—	1300	
1. XII.	1500	1015	71.9	243	—	—	—	1700	
5.	1600	1015	—	240	—	—	—	1550	
11.	—	—	72.4	—	1043.6	α=1031 β=1031.2	—	—	

TABLE III (TO CASE III)

Date	Quantity of Urine	Specific Gravity	Body Weight in Kg.	Oxygen Consumption per Minute	Ingestion of Liquids	Specific Gravity of Blood	Specific Gravity of Serum	Blood Corpuscles	Hæmoglobin	
16.	—	—	—	226	—	—	—	—	—	Fore-Period. Average Oxygen Consumption in 6 Tests =217.5 cc.
17.	2325	1016	—	226	2750	—	—	—	—	
18.	2600	1014	—	221	2750	α=1044.2 β=1043.4	α=1028.8 β=1028.2	3988000	Hæmoglobin =32%	
19.	2225	1020	—	220	2750	—	—	—	—	
20.	1400	1014	49.0	199	2000	—	—	—	—	
23.	930	1025	48.9	213	1000	—	—	—	—	
24.	725	1030	48.5	216	1000	—	—	—	—	Thirst Period. Average Oxygen Consumption in 11 Tests=205.6 cc.
26.	690	1025	48.8	200	1000	—	—	—	—	Light Bath
28.	700	1022	48.1	214	800	—	—	—	—	
29.	600	1026	48.0	207	800	—	—	—	—	
30.	700	1020	48.2	195	800	—	—	—	—	Light Bath
2.V.	600	1025	47.7	222	800	—	—	—	—	
3.	800	1021	47.4	208	800	—	—	—	—	
5.	700	1027	47.5	194	800	—	—	—	—	
6.	900	1020	47.2	200	800	—	—	—	—	
7.	650	1027	47.2	204	800	α=1048.0 β=1049.3	α=1030.6 β=1031	4112000	40%	Light Bath
9.	1100	1020	47.0	202	—	—	—	—	—	
12.	2000	1010	—	194	2000	—	—	—	—	After Period. Average Oxygen Consumption in 10 Tests =202.6
14.	1350	1020	—	198	1750	—	—	—	—	
16.	1600	1015	—	199	1800	—	—	—	—	
20.	—	—	—	203	—	—	—	—	—	
25.	—	—	—	210	—	—	—	—	—	
26.	—	—	—	200	—	—	—	—	—	
27.	—	—	—	198	—	—	—	—	—	
28.	—	—	—	198	—	—	—	—	—	
29.	—	—	—	209	—	—	—	—	—	
30.	—	—	48.5	217	—	—	—	4400000	35%	

TABLE IV (TO CASE IV)

Date	Quantity of Urine	Specific Gravity	Body Weight in Kg.	Oxygen Consumption per Minute	Blood Density	Serum Density	Ingestion of Liquids	
12. VII.	—	—	—	216.3	—	—	2000	Fore-Period. Average Oxygen Consumption in 8 Tests =209.4 cc.
13.	—	—	—	209.2	—	—	2000	
14.	1500	1012	—	207.5	—	—	2000	
15.	1900	1010	—	204.3	—	—	2000	
16.	1000	1012	—	209.2	—	—	2000	
17.	1000	1012	—	221.1	—	—	2400	
18.	1200	1015	—	199.6	—	—	1200	
19.	1000	1010	—	208.5	—	—	750	
21.	1000	1012	50.7	198.2	α=1046.3 β=1046.1	α=1027.1 β=1027.5	900	Thirst-Period. Average Oxygen Consumption in 11 Tests=196.6 cc.
25.	800	1020	—	206.9	—	—	700	
26.	1200	1020	—	202.4	—	—	500	
27.	775	1023	—	199.4	—	—	500	
28.	800	1022	—	190.8	—	—	750	
29.	800	1026	—	199.8	—	—	750	
30.	760	1025	—	190.6	—	—	750	
31.	800	1027	—	180.4	—	—	750	
1. VIII.	750	1028	48.0	190.3	α=1056.8 β=1056.3	α=1033.5 β=1033.5	750	
2.	750	1027	—	206.5	—	—	750	
4.	1000	1010	—	197.7	—	—	1500	After-Period. Average Oxygen Consumption in 13 Tests=202.7 cc.
5.	1600	1012	—	196.6	—	—	1800	
6.	—	—	—	200.6	—	—	1650	
7.	—	—	—	202.5	—	—	2000	
8.	—	—	—	206.2	—	—	2000	
9.	—	—	—	202.5	—	—	—	
10.	—	—	—	206.9	—	—	—	
15.	—	—	—	204.4	—	—	—	
17.	—	—	—	210.5	—	—	—	
21.	—	—	—	204.5	—	—	—	
27.	—	—	—	208.2	α=1056.8 β=1057.4	α=1029.7 β=1029.9	—	
30.	—	—	—	198.8	—	—	—	
3. IX.	—	—	—	195.4	—	—	—	
5.	—	—	—	198.8	—	—	—	

TABLE V (TO CASE V)

Date	Quantity of Urine	Specific Gravity	Body Weight in Kg.	Oxygen Consumption per minute	Ingestion of Liquids	Blood Density	Serum Density	
4.X.	1300	1020	—	189.3	1500	18	—	Fore-Period. Average Oxygen Consumption in 10 Tests=208.7 cc. per Minute
7.	1500	1016	—	208.5	1700	—	—	
8.	1400	1016	50.6	210.8	1800	—	—	From Oct. 8 to 10 Menstruation
9.	1200	1015	—	182.0	1400	—	—	
12.	1300	1015	—	210.2	1150	—	—	
13.	1600	1010	—	213.7	1450	—	—	
15.	800	1017	—	211.5	1200	—	—	
16.	900	1018	50.4	191.2	1100	—	—	
17.	—	—	—	231.0	—	—	—	
18.	900	1020	50.5	216.3	1000	—	—	
19.	750	1020	50.5	202.1	— 750	α=1062.9 β=1062.9	α=1030.8 β=1031.8	
20.	675	1024	50.5	196.6	500	—	—	Thirst-Period. Average Oxygen Consumption=196.5 cc. per Minute
21.	450	1021	50.2	201.0	500	—	—	
22.	400	1025	49.2	201.5	500	—	—	
23.	545	1023	49.2	186.3	300	—	—	
26.	400	1021	49.0	202.6	300	—	—	
27.	620	1022	48.2	195.3	300	—	—	
28.	510	1022	48.3	194.0	300	α=1066.5 β=1066.3	α=1034.8 β=1034.8	
29.	500	1020	49.0	189.7	1350	—	—	After Period. Average of 4 Determinations=202.9 cc. per Minute.
30.	700	1020	48.2	209.3	1250	—	—	
3.XI.	1000	1015	49.3	190.9	950	—	—	
4.	1400	1016	50.3	205.6	1750	—	—	
5.	1700	1015	51.0	206.0	1800	—	—	

TABLE VI (TO CASE VI).

Date	Body Weight in Kg.	Oxygen Consumption per Minute	Body Weight in Kg.		
29. VII.	98.0	259.7	98.0		
30.	—	272.6	—		
31.	98.3	257.2	98.3		Fore-Period. Average of 6 Tests=262.5 cc.
1. VIII.	—	265.4	—		
2.	—	255.6	—		
3.	98.1	264.3	98.1		
4.	98.0	247.5	98.0		
5.	98.0	253.6	98.0	Menstruation	
6.	97.2	274.3	97.2		Main-Period. (500 cc. of Liquid.) Average of 6 Tests=240.5 cc.
7.	97.3	229.8	97.3		
8.	96.9	237.8	96.9		
9.	96.5	253.8	96.5		

TABLE VII (TO CASE VII)

Date	N. of the Food	Quantity of Urine	Specific Gravity	N. of the Urine	N. of the Stools	Balance	Oxygen Consumption per Minute	Body Weight	
17. XII.	—	—	—	—	—	—	214.9	72.7	
18.	—	—	—	—	—	—	203.5	72.4	Fore-Period. Average of 8 Tests=214.1 cc.
19.	13.7106	—	—	11.337	1.1269	+1.2467	216.5	72.1	
20.	13.7319	—	—	12.448	1.1269	+0.1570	—	72.0	
21.	13.7976	—	—	11.442	1.1269	+1.2287	—	71.8	
22.	14.0595	—	—	9.872	1.1269	+3.0606	—	71.3	
23.	14.1033	950	1020	10.4007	1.1269	+2.5757	213.2	72.0	
24.	14.1033	1350	1015	9.9415	1.1269	+3.0349	—	72.7	
25.	13.7080	1180	1020	10.771	1.1269	+1.8101	220.0	72.7	
26.	13.8175	1640	1013	9.9186	1.1269	+2.7720	219.1	72.6	
27.	13.6861	1630	1014	11.9122	1.1269	+0.6470	204.1	72.4	
28.	13.5713	1430	1015	10.931	1.1269	+1.5134	—	72.4	
	138.2891			108.9740	11.2690	18.0461			
	Balance:								
	Intake..................			138.2891					
	Output in urine and fæces			120.2430					
				+18.0461	= + 1.8046 per day				
29.	14.0381	760	1024	11.4484	1.0376	+1.5521	221.8	72.4	
30.	13.8410	670	1026	12.0252	1.0376	+0.7782	207.5	72.4	
31.	14.3012	600	1030	11.9286	1.0376	+1.3350	201.9	72.2	Thirst-Period. Average of 9 Tests = 198.9 cc.
1. I.	14.5202	570	1029	12.4810	1.0376	+1.0016	207.3	72.4	
2.	13.9039	560	1029	12.5127	1.0376	+0 3536	201.8	72.3	
3.	14.0696	550	1029	12.5350	1.0376	+0.4970	194.6	72.3	
4.	14.1791	510	1035	13.2466	1.0376	—0.1051	186.8	72.3	
5.	14.2448	520	1034	12.8526	1.0376	+0.3546	—	72.2	
6.	13.8244	560	1033	12.7950	1.0376	—0.0082	198.8	72.2	
7.	13.8682	560	1035	12.7930	1.0376	+0.0376	191.6	72.2	
	140.7905			124.6181	10.3760	5.7964			
				—	—	—			
8.	—			—	—	—	200.0	—	After-Period. Average of 4 Tests = 199.1 cc.
12.	—			—	—	—	195.6	—	
15.	—			—	—	—	206.8	—	
17.	—			—	—	—	193.1	—	
22.	—			—	—	—	201.7	—	
	Balance:								
	Intake..................			140.7905					
	Output in urine and fæces			134.9941					
				+5.7964	= +0.5796 per day				

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